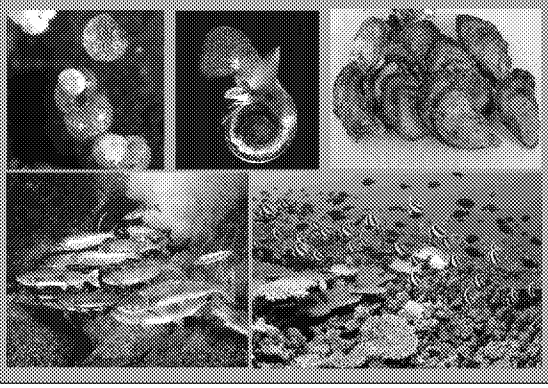
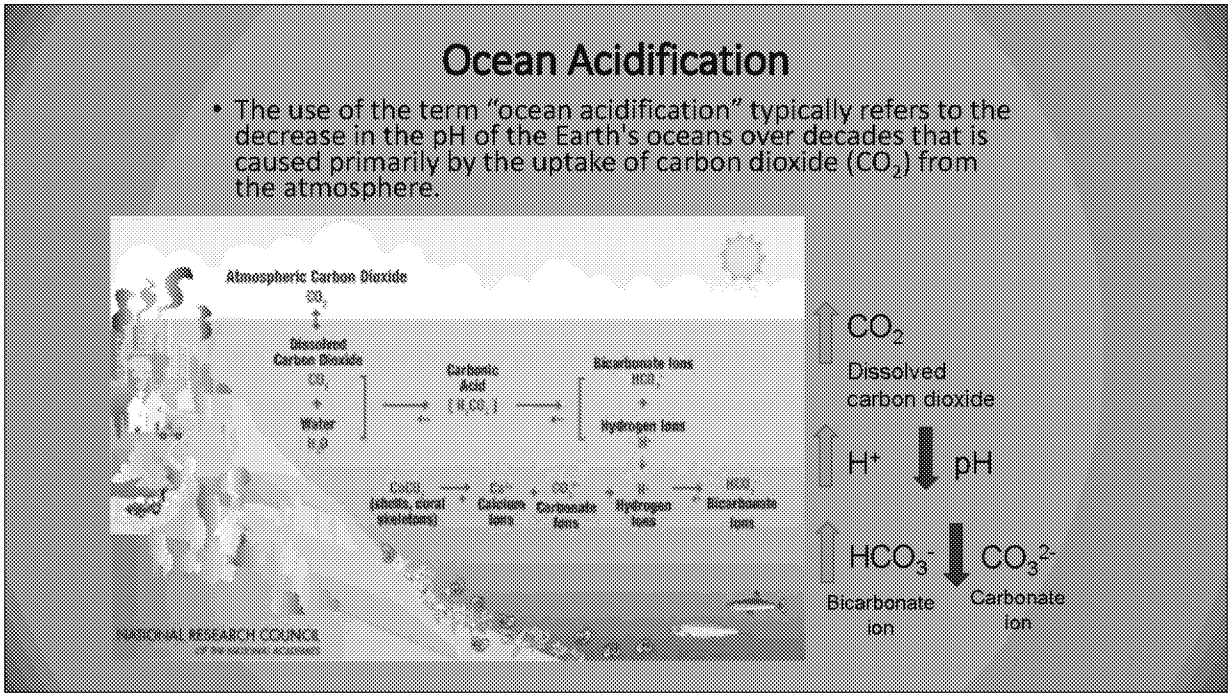
Coastal/Ocean Acidification: Current State of the Science and Policy

RA Briefing

May 7, 2018

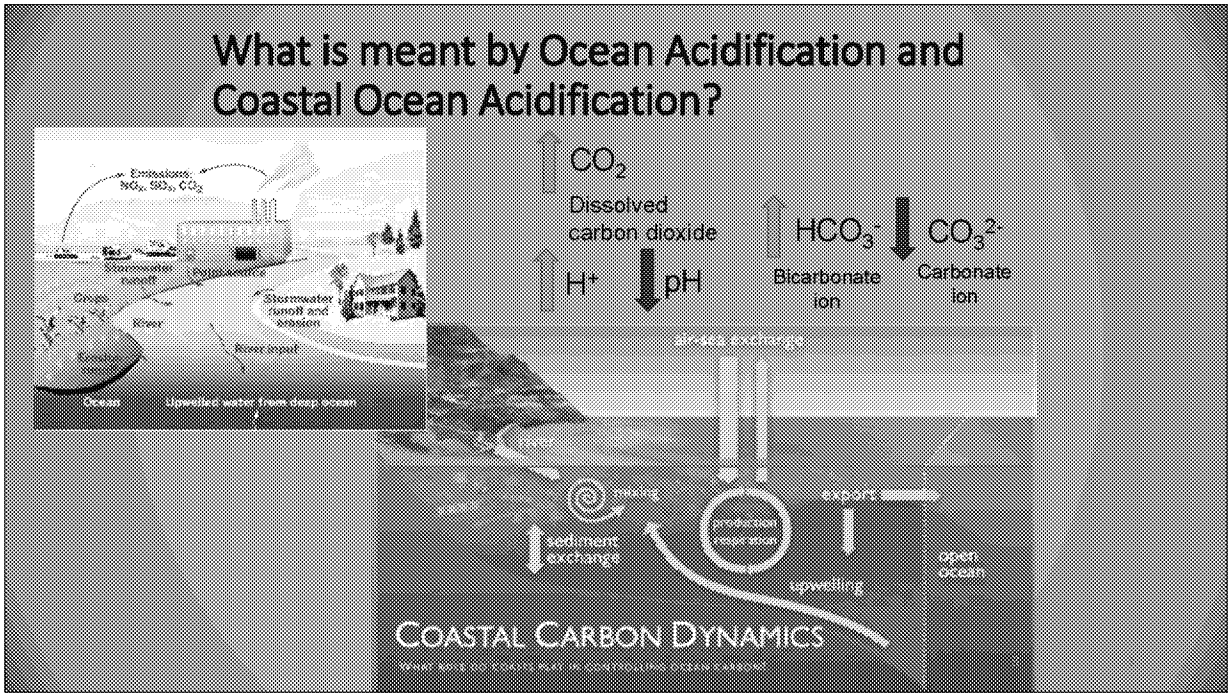




Acidification refers to lowering pH from any starting point to any end point on the pH scale. Term is used to refer to the addition of an acid to a solution, regardless of the solution's pH value. Similar in the use of "warming." If the air temps moves from -20C to -0C (-4F to 32F), it is still cold, but we call it "warming."

In summary, the chemical changes in seawater resulting from increased atmospheric CO2 concentrations include increases in the concentrations of dissolved (or aqueous) carbon dioxide, hydrogen ions, and bicarbonate ions, and decreases in the carbonate ion concentration and pH.

pH is a logarithmic scale so that a pH change of 1 unit means a 10-fold change in acidity



The use of the term "ocean acidification" typically refers to the decrease in the pH of the Earth's oceans over decades that is caused primarily by the uptake of carbon dioxide (CO2) from the atmosphere.

The same carbon chemistry changes occur, but the causes, magnitude, and speed of coastal OA differ in complexity and understanding than OA due to other exacerbating factors (e.g., eutrophication from nitrogen and phosphorus pollution, upwelling).

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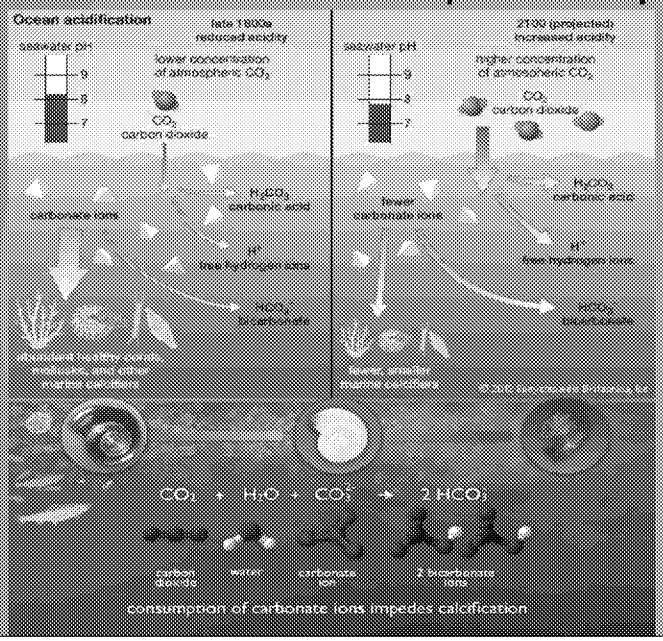
NOAA PMEL (http://www.pmel.noaa.gov/co2/story/Coastal+Carbon+Dynamics)

Acidification Impacts to Aquatic Life

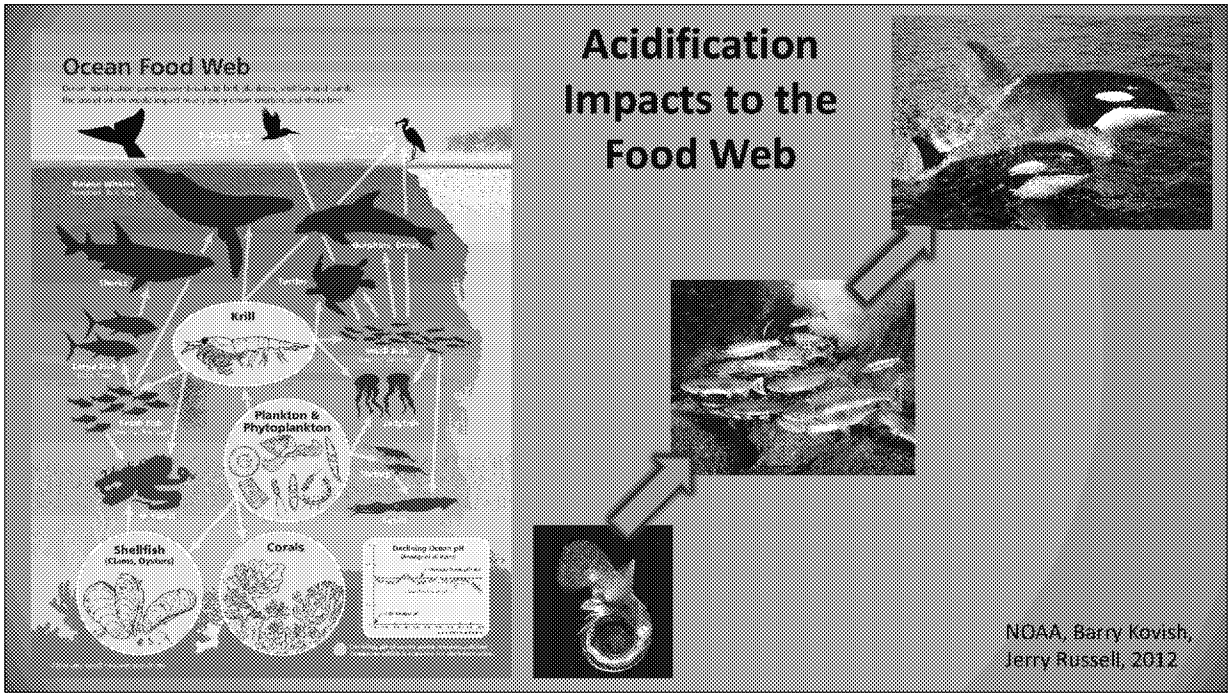


*Acidification/decrease in carbonate ions likely greater in coastal waters influenced by local, land-based inputs of nutrients and organic carbon

CO_2
Dissolved carbon dioxide

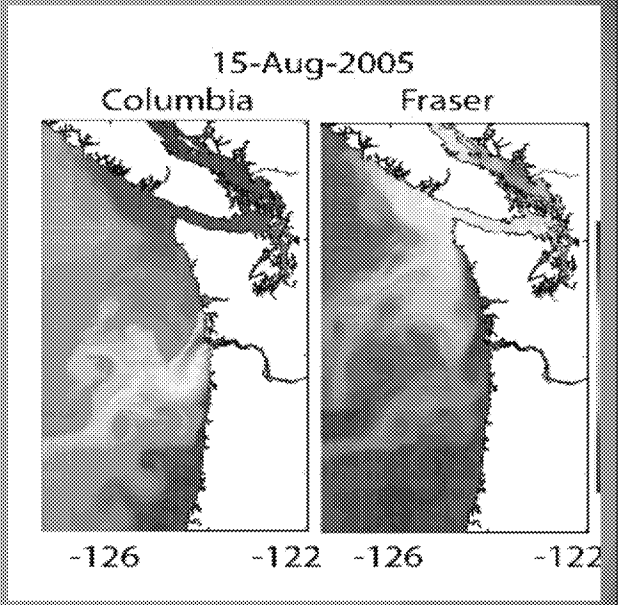
H^+ ⬇ pH

HCO_3^- ⬇ CO_3^{2-}
Bicarbonate ion
Carbonate ion


Ocean Food Web
Krill
Plankton & Phytoplankton
Shellfish
(Clams, Oysters)
Corals
Acidification Impacts to the Food Web
NOAA, Barry Kevish, Jerry Russell, 2012

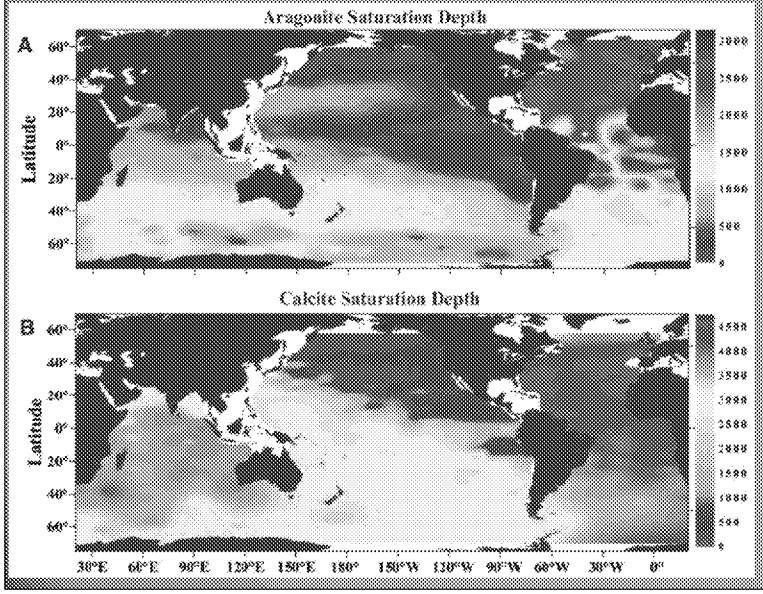
The West Coast Context

- The eastern Pacific coast is vulnerable to OA for several reasons:
  - Natural upwelling events push deep corrosive waters to the surface.
  - Complex bathymetry, estuarine circulation, large scale eddies and multiple river plumes add to the dynamic.
  - Coastal inputs such as organic matter runoff and air emissions contribute to the problem.



Davis *et al., 2014*

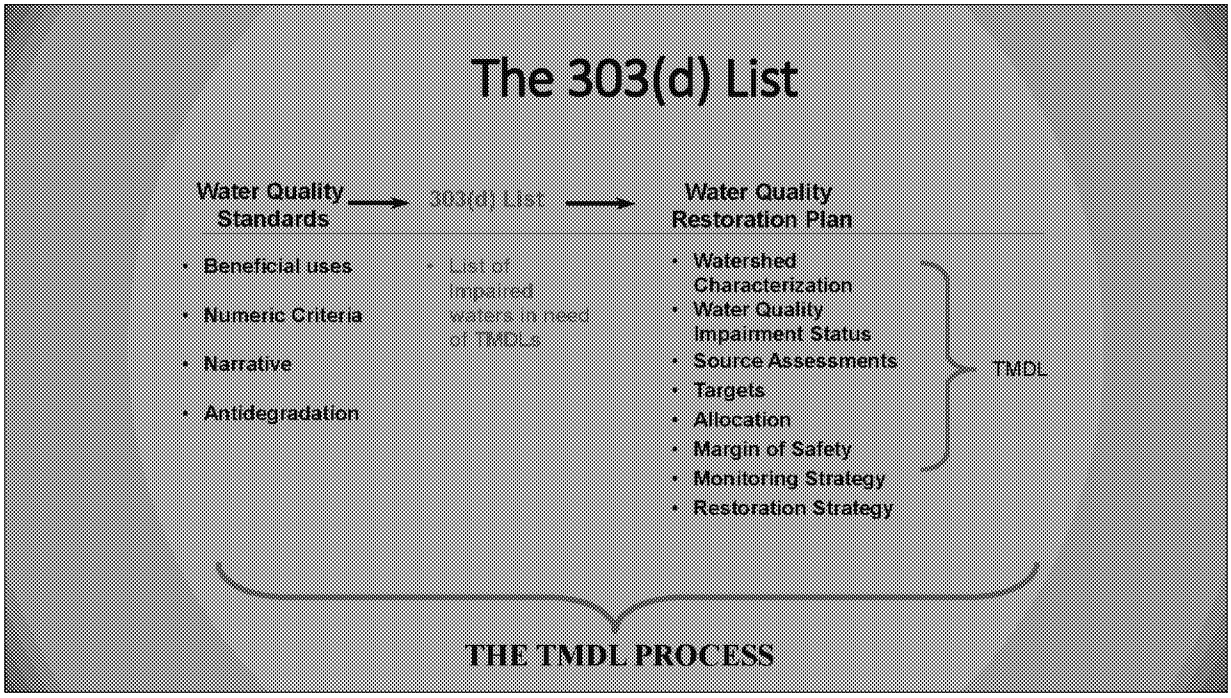
Aragonite Saturation



- **Aragonite** is a crystalline form of calcium.
- The **saturation state** is a measure of the potential for dissolution.
- **Aragonite saturation state**-Ωar- less than 1 = dissolution.
- **Saturation** horizon-depth where Ωar = 1
- **Upwelling** pushes horizon closer to the surface.

Feely *et al.*, 2004

The 303(d) List



The 303(d) List

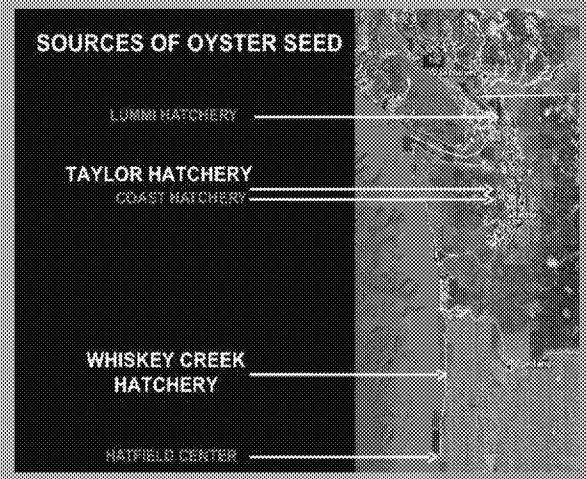
- **Category 1:** All designated uses are supported
- **Category 2:** Some, but not all of the designated uses are supported
- **Category 3:** Insufficient data or information to make a determination
- **Category 4:** Water is impaired, but a TMDL is not needed
  - **4a:** Water has an approved TMDL
  - **4b:** Water has other approved pollution control requirements in place.
  - **4c:** A use is impaired, but the impairment is not caused by a pollutant.
- **Category 5:** Water is impaired and in need of a TMDL

OA and the 303(d) List

- State compares data to WQS
  - Numeric criteria
  - Narrative criteria
- If the WQS is not attaining, the water goes into Category 5
- A TMDL assessment is conducted
  - Determines extent of the impairment
  - Determines all contributing sources, including local ones
  - Determines best restoration path forward

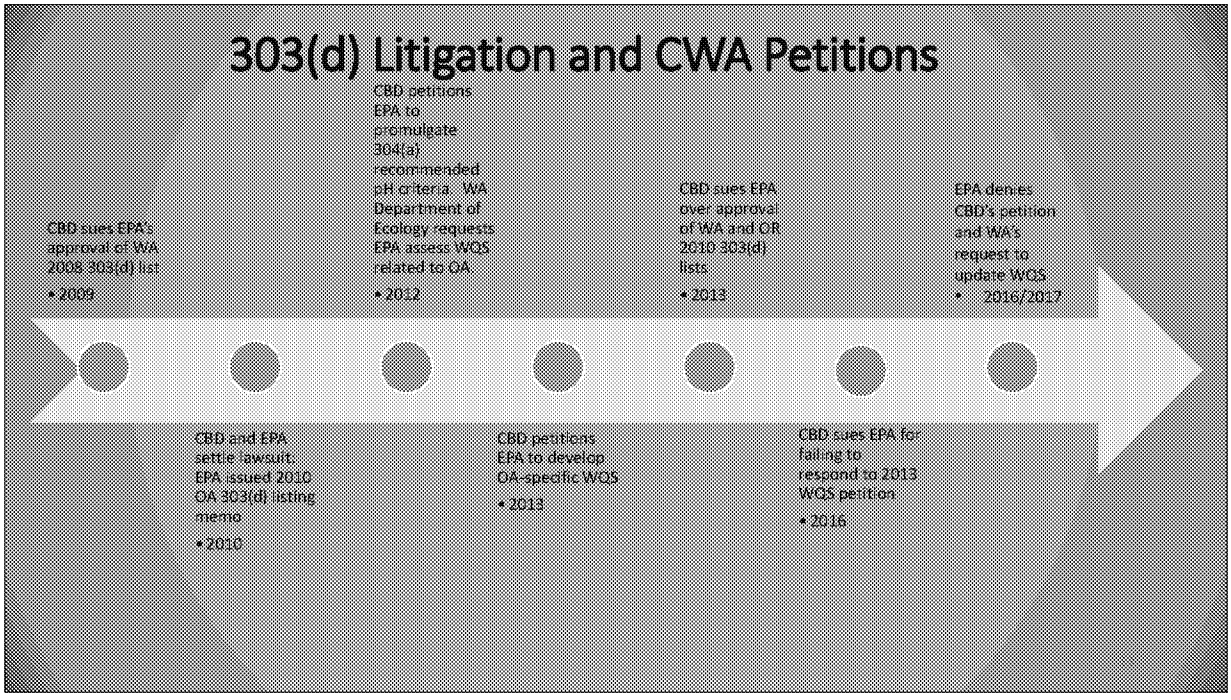
The 2010 OR and WA 303(d) Lists

- R10, OR and WA received a great deal of OA data and information, primarily from the Center for Biological Diversity.
- R10 did not feel OA listings could be added because the data was from:
  - Geographically distant areas or species not found in the PNW
  - Outside state jurisdiction and too hydrogeographically distinct to be extrapolated
  - Laboratory experiments
  - Hatcheries



Hatchery Impacts

- Lack of sufficient larval oyster seed in recent years has threatened the $278 million PNW shellfish industry (Pacific Shellfish Growers Assoc., 2010).
- The Whiskey Creek Hatchery, Netarts Bay, OR mortality events
- Taylor Shellfish, 80% decline in Dabob Bay, WA
- Willapa Bay natural recruitment failures


303(d) Litigation and CWA Petitions
CBD sues EPA's approval of WA 2008 303(d) list
• 2009
CBD and EPA settle lawsuit. EPA issued 2010 OA 303(d) listing memo
• 2010
CBD petitions EPA to promulgate 304(a) recommended pH criteria. WA Department of Ecology requests EPA assess WQS related to OA.
• 2012
CBD petitions EPA to develop OA-specific WQS
• 2013
CBD sues EPA over approval of WA and OR 2010 303(d) lists.
• 2013
CBD sues EPA for failing to respond to 2013 WQS petition
• 2016
EPA denies CBD's petition and WA's request to update WQS
• 2016/2017

The Current Listing Situation in R10

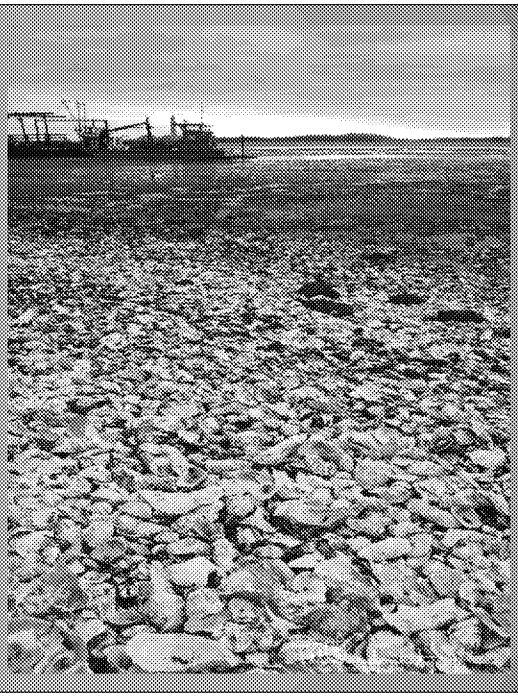
Deliberative Process / Ex. 5

R10 Lists Cont'd

Deliberative Process / Ex. 5

Fostering Integration and Communication

- **Internal Collaboration**
  - R10 OA workgroup
  - EPA Ocean and Coastal Acidification Coordination Workgroup
  - Close coordination with ORD



R10 External Collaboration

- Blue Ribbon Panel (2012) and Marine Resources Advisory Council(MRAC) (2013)—Linda Anderson-Carnahan is R10's representative
  - Since 2013 WA Legislature appropriated $3.55 million towards ocean acidification work
  - Washington Ocean Acidification Center at UW
- Oregon Ocean Acidification and Hypoxia Monitoring Group- Cheryl Brown(ORD) is R10's representative
- Stanford University OA Water Quality Goals Workshop in 2016

MRAC Comprehensive Strategy and 2017 Addendum to Blue Ribbon Panel Report

- Reduce carbon emissions
- Reduce local land-based contributions
- Increase our ability to adapt and to remediate impacts
- Invest in monitoring and scientific investigations
- Inform, educate, and engage stakeholders, the public, and decision makers
- Maintain a sustainable and coordinated focus

R.A.R.E. Projects

Toward a unified understanding of coastal acidification processes in Puget Sound

Regional Technical Contact: Rochelle Labiosa; **ORD Lead:** Cheryl Brown

Collaborators: Tulalip Tribes, Oregon State University, USGS

- Used field observations & modeling to demonstrate that the ability of seagrass habitat to buffer natural extremes of CO2 is reduced by coastal acidification.
- Reduced buffering results in impacts to water chemistry, including decreased pH and aragonite saturation state beyond natural ranges.

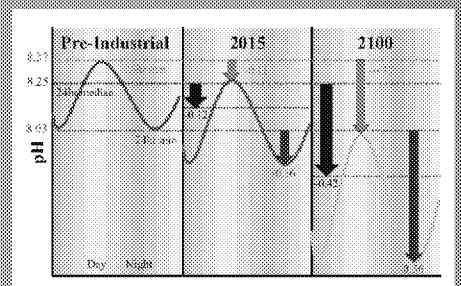


Fig. 4. Representative diel curves illustrating changes in daily pH medians (black), maximums (green), and minimums (red) from preindustrial values for years 2015 and 2100. Daily pH minimums have larger reductions than corresponding medians and maximums due to the additive anthropogenic and respiratory carbon reducing the pH buffering capacity of the system. Values shown are mean changes for the dry season of the designated year.

Identifying Local Factors Which May Exacerbate Coastal Acidification in Tillamook Estuary (Oregon)

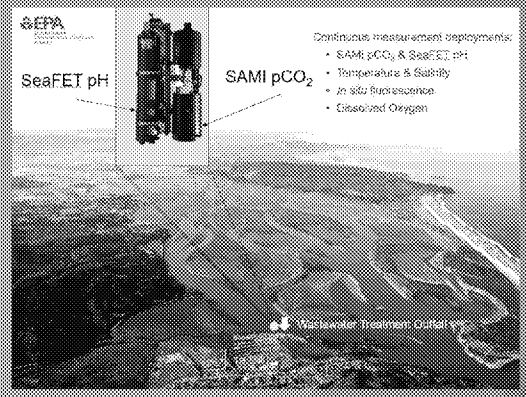
Regional Technical Contact: Rochelle Labiosa; **ORD Lead:** Cheryl Brown
Collaborators: Tillamook Estuaries Partnership, Oregon Dept. Env. Quality, USGS, US Navy Research Laboratory

Goals:

1) Identify sources of nutrients, bacteria, and organic material

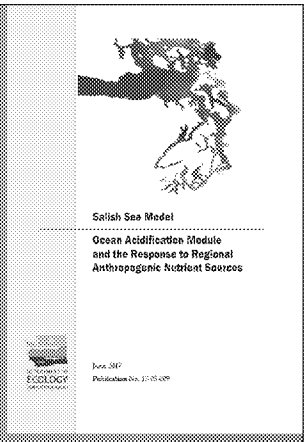
2) Role of local drivers on carbonate chemistry & oxygen dynamics

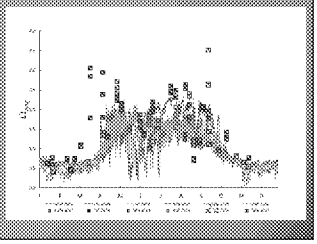
3) Role of nutrients and organic matter in enhancing acidification



Salish Sea Model Assessment

- Question from WA Blue Ribbon Panel:
  - What is impact of local nutrient/carbon sources on pH and aragonite saturation?
- Tool: Salish Sea Model (Ecology/PNNL) – EPA funded
- Results
  - Regional nutrient sources affect acidification in the Salish Sea.
  - Predicted impacts to pH and DIC are comparable to changes caused by increasing global atmospheric CO2 to date.





Next Steps

- **Deliberative Process / Ex. 5**
- Engage with other coastal Regions to coordinate responses and rationales.
- Continue to review new data and information as they become available.
- Continue to work with researchers to influence sampling design.

Photo credit: DOI